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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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(54) Title: METHOD OF PRINTING AN IMAGE ONTO A THREE-DIMENSIONAL SURFACE

(57) Abstract: A method of printing an image onto a three dimensional surface is disclosed. An image is printed onto a transfer element (S12) and the transfer element is heated to make it more flexible (S26). The heated transfer element is vacuum formed onto an article to be printed with the image (S16) and the transfer element is heated to cause sublimation of the image onto the article (S20).

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METHOD OF PRINTING AN IMAGE ONTO A THREE-DIMENSIONAL SURFACE

The present invention relates to printing an image onto a three dimensional surface, and relates particularly, but not exclusively, to printing a complex image on to non-planar surfaces of shaped plastic articles.

Existing techniques for producing an image on a three dimensional article such as parts for car interiors or casings for mobile phones include moulding an image printed on a transparent film onto the article as part of the moulding stage of production of the article. This technique suffers from the disadvantage that the image to be printed on the article must be decided at the point of production of the article and cannot be printed onto the article subsequently to moulding, and whenever a new image is to be introduced on to a new line of articles, the production process must be interrupted so that the new films containing the new images can be introduced. For example, a mass produced article which is sold in various different countries is often produced at a single location and then distributed. Where regional variations in taste or information required on such an article occur, these variations must be included as part of the production process rather than by being printed locally once they have reached their destination country or region. This significantly increases the production costs involved.

An alternative technique involves floating a thin film containing the image that is required to be printed onto the three dimensional article on a bath of liquid. The article on to which the image is to be printed is dipped through the floating image into the bath and the image is thereby attached to the article. This method of printing suffers from the drawback that it is difficult to consistently reproduce the same images in the same position on a series of identical articles. If information is being presented on the article,

this can present a significant drawback. This technique also suffers from the problem that the image is easily creased as the article is dipped into it, or as the image is laid on to the bath of liquid, as a result of which an uneven image is often produced on the article. Because of these problems, the levels of wastage of articles resulting from this technique are unacceptably high.

An existing method of printing on to a planar surface involves the steps of printing an image onto a transfer sheet, and bringing the sheet into contact with the planar surface onto which the image is to be printed. Once in position a heated element is placed against the transfer sheet. The heat of the element causes the pigments of the inks with which the image is printed to sublime, i.e. change from the solid phase to the gas phase without entering liquid phase. However this method is unsuitable for printing onto non-planar surfaces as the image will not come into contact with all of the surface until a moulded heating element is brought into contact with the sheet. For many non-planar surfaces this will cause the transfer sheet to become distorted or creased, resulting in unsatisfactory transfer of the image.

Preferred embodiments of the invention seek to overcome the above described disadvantages of the prior art.

According to the present invention there is provided a method of printing an image onto a three-dimensional surface, the method comprising:-

printing an image onto a transfer element;

heating said transfer element printed with said image to make the transfer element more flexible;

applying the heated transfer element to said three-dimensional surface with substantially uniform pressure across the area of

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contact between said transfer element and said surface such that the image faces the surface; and

heating the transfer element to at least partially transfer the image from the transfer element to the three-dimensional surface.

By providing a method of transferring an image from a transfer element applied to a surface of an article with substantially uniform pressure over the area of contact between the transfer element and the surface and by applying heat to said transfer element, the advantage is provided that consistently repeatable printing results can be obtained in a method which can also be used to print on to a three dimensional object. Because of consistency and accuracy with which the image can be located on to the article, the wastage from incorrectly placed images is significantly reduced. Furthermore, this technique is easily adapted to short print runs and the printing of images onto articles on which it had not originally been intended that images would be printed.

In a preferred embodiment, said transfer element has a carrier coating and a supporting layer, and said image in printed onto said carrier coating.

The supporting layer may comprise a sheet of Amorphous Poly Ethylene Terephthlate.

The supporting layer may further comprise a metallised coating on at least one surface thereof.

The carrier coating may be applied to said supporting layer as an aqueous solution.

The carrier coating may be applied to a thickness of substantially 5 to substantially 250 microns.

The method may further comprise the step of applying a receptor coating to said surface.

The method preferably further comprises the step of applying a base coat to said surface prior to application of said receptor coating to said surface.

By providing a base coat to the image, articles formed from substances to which the receptor coating will not attach can be printed on to. The base coat can also be used to apply a base colour to the articles.

The base coat may be applied by a spraying process.

In a preferred embodiment said base coat is applied to give an average thickness of up to substantially 300 microns of base coat.

In a preferred embodiment said base coat comprises substantially the ratios 100 parts paint primer, 10 to 40 parts catalyst and 15 to 85 parts solvent.

In another preferred embodiment said receptor coating is applied by a spraying process.

In a further preferred embodiment said receptor coating is applied to an average thickness of up to substantially 300 microns.

In a further preferred embodiment said receptor coating comprises substantially the ratios 100 parts paint primer, 1 to 40 parts catalyst and 15 to 85 parts solvent.

In a preferred embodiment said receptor coating is substantially translucent after application to said surface.

The step of applying the transfer element to the three-dimensional surface preferably includes vacuum forming the transfer element to the surface.

In a further preferred embodiment said step of printing an image onto said transfer coating is carried out by means of a digital printer.

Digital printing is known as a non-impact printing technique because the only material to come into contact with the substrate being printed on is the ink, whereas an impact printing technique such as screen printing involves contact between the screen and the substrate as well as the ink. As a result, digital printing provides greater flexibility, the images being printed are more easily altered as it is not necessary to produce, for instance, a new screen for each new image that is to be produced. Where a random element to an image is important, such as when a wood grain is printed, it is possible to produce three dimensional articles printed with a wood grain which has been randomly generated by the computer which is providing the data to the printer, thus each piece of printed plastic appears unique such as real wood does. Furthermore, the computer can be used to manipulate that data so as to compensate the image for the stretching of the transfer element that occurs as a result of the vacuum forming process. This is only possible because the vacuum forming process results in consistent distortion of the transfer element and image.

In a preferred embodiment said digital printer has at least one piezoelectric printing head.

The piezoelectric printing head causes very little heating of the ink as it is printed and as a result if an ink pigment which transfers by sublimation is used, there is little degradation of the pigment during the printing process.

In another preferred embodiment said image is formed from at least one pigment capable of sublimation when heated to a predetermined temperature.

By providing an ink in which the pigment is converted from solid to gas by the application of heat, the advantage is provided that the clarity of image produced as the molecules of pigment transfer from the second coating on the transfer element to the adhesion promoting coating is improved. Where the pigment transfers from transfer element to the adhesion promoting coating as a liquid, or where the pigment is converted from solid to liquid and then from liquid into gas, before transferring, there is an increased likelihood of accidental irregularities occurring in the printed image.

In a preferred embodiment the step of applying heat to said transfer element occurs after said vacuum forming step at a temperature so as to cause the sublimation of the or each said pigment.

In another preferred embodiment heat is applied to said transfer element at a temperature of between 50 and 450°C for between 10 seconds and 20 minutes.

A preferred embodiment further comprises the step of supporting, by means of a mould, the article onto which said image is to be printed on a surface thereof other than the surface to be printed on.

Where the article onto which the image is to be printed is not a heat set material, that is it is a material which is liable to melt when subjected to the heat used to facilitate the printing process, providing a mould to support the article offers the advantage that such articles maintain their shape and are not distorted by the heating and vacuum forming process. Furthermore, since the article is accurately located on the mould, the further advantage is also provided that the

printed transfer element can be accurately located on to the article with a consistent repeatability.

Another preferred embodiment further comprises the step of controlling the temperature of said mould.

By controlling the temperature of the mould, the advantage is provided that the mould is not caused to expand by an increase in temperature and the article located thereon will continue to fit accurately on the mould throughout the printing process.

A further preferred embodiment further comprises the step of heating said transfer element prior to the step of vacuum forming said transfer element to said surface.

By heating the transfer element prior to vacuum forming it over the article to be printed, the advantage is provided that the transfer element can be formed consistently and evenly over the article on to which it is to be printed.

In a preferred embodiment said transfer element is heated to a temperature between 150 and 600°C for between 1 and 30 seconds.

In a preferred embodiment, the step of applying said heat to said transfer element comprises providing a moulded heating chamber, a surface of which has similar dimensions to said surface of the article, and locating said chamber adjacent the surface of the article, without contact between said moulded heating chamber and said transfer element.

By providing a moulded heating chamber which matches the contours of the surface which is to be printed on to, the advantage is provided that an even heat can be provided across the whole of the transfer element which results in an even transfer of the image.

The moulded heating chamber may have regions which radiate heat at different rates.

This provides the advantage of offering greater control of the rate of image transfer in specific regions of the surface. For example, by providing a region which radiates heat more rapidly, the rate of image transfer can be increased, which has advantages in irregularly shaped parts of the surface.

In another preferred embodiment the step of applying heat to said transfer element comprises applying said heat by means of hot air.

By providing a heat source for the transfer element in the form of hot air, the advantage is provided that an adequately even supply of heat can be provided to different shaped articles without the need for a separate moulded heating chamber to be formed for each type of article.

The hot air may be applied to the transfer element at a pressure greater than atmospheric pressure.

This provides the advantage of improving the transfer of the image onto irregularly shaped parts of the surface.

A preferred embodiment further comprises the step of applying a finishing coat to said article after removal of said supporting layer from said article.

By providing a finishing coat to the article once the image has been transferred, the advantage is provided that the transferred image is protected from abrasion.

In a preferred embodiment said finishing coat is applied by a spraying process.

In another preferred embodiment said finishing coat is applied to an average thickness of up to 500 microns.

In a further preferred embodiment said finishing coat comprises substantially the ratios of 100 parts paint primer, 10 to 40 parts catalyst and 15 to 85 parts solvent.

A preferred embodiment further comprises the step of adding an ultraviolet radiation filtering additive to said finishing coat.

By providing a UV filtering substance within said coating, this provides the advantage of protecting the image from UV degradation, particularly that caused by prolonged exposure to sunlight.

In a preferred embodiment the image is printed onto a non-planar surface of the article.

A preferred embodiment of the invention will now be described, by way of example only and not in any limitative sense, with reference to the accompanying drawings in which:-

Figure 1 is a schematic flow diagram of a printing process embodying the present invention;

Figure 2 is a perspective view of an apparatus used to carry out the process of Figure 1; and

Figure 3 is a cross-sectional view of the apparatus of Figure 2.

Figure 1 shows a method for applying an image to a non-planar surface of an article, for example to the casing of a mobile telephone. A receptor coating is applied to the article at step S10. An image is printed at step S12 onto a transfer element which has had a carrier coating in the form of an

aqueous coating applied to it at step S14. To assist in the vacuum formation of the transfer element over the article at step S16, the transfer element is clamped in position and a radiant heat of between 150 and 300 degrees Celsius is applied to the transfer element for a period of between 1 and 30 seconds, by way of preheating the transfer element at step S26. This makes the transfer element more flexible and allows it to form more easily over the article. The transfer element is vacuum formed at step S16 in order to apply substantially uniform pressure over the area of the transfer element to minimise inconsistencies in transferring the image from the transfer element to the article. Because the transfer element is clamped in a standard position and the article can be located in a set position, for instance if it is supported by a mould, it is possible to accurately locate the image on the transfer element on to the printed article.

Heat is applied again at step S18 while the transfer element is being vacuum formed, thus causing the sublimation of pigments in the ink printed on the transfer element, resulting in a transfer of the image from the transfer element to the article at step S20.

At step S18, heat is applied at a temperature higher than the heating temperature at step S16, typically between 150 and 450 degrees Celsius to the transfer element, whilst it is located on the article, for between 1 and 600 seconds. The heat can be applied by having a moulded heat chamber which is formed around the product without touching it and therefore applies an even heat to the whole of the transfer element in contact with the article. Alternatively, hot air can be blown over the article under pressure, thereby producing a reasonably even heat over the article. As the temperature of the transfer element increases the pigment within the ink on the transfer element is caused to convert directly from its solid form to a gas (sublimation) in the gaseous form the pigment transfers from

the aqueous coating of the transfer element to the adhesion promoting coating on the article at step S20.

Once the image has transferred from the transfer element to the article the transfer element can be removed at step S28. A protective coating can then be applied at step S30 to the article to protect the image. This final coating can also contain a UV protection to protect the image from ultra-violet radiation.

It has been found that the image can be applied directly to some plastic materials using the method described above. However, for certain articles it may be necessary or advantageous to apply a base coat to the article, such as at step S22, on to which the receptor coating is then added at step S10. The base coat will typically be white. The receptor coating is applied by spraying and typically contains 100 parts primer to 10 to 40 parts catalyst and 15 to 85 parts solvent. The base coat should not exceed 300 microns in thickness.

The constituents of the above described receptor coating, as applied, would typically consist of the following. The primer would generally contain an acrylate resin, pigments of silica and/or a polyamide, and a mixed hydrocarbon solvent. The hydrocarbon solvent typically contains isobutanol, -butanol, methylisobutylketone, butylacetate, isobutylacetate, xylene and napha light. The catalyst contains polyisocyanate, ethylacetate, methoxypropylacetate and xylene. The solvent typically consists of a mixture of isobutylacetate, methoxypropylacetate and isobutanol.

The support layer of the transfer element is metallised Amorphous Poly Ethylene Terephthalate (APET), and the aqueous coating applied at step S14 is in the form of an aqueous solution of polyvinyl polymers and may also contain synthetic silica, surfactants and optical brightening agents. The transfer element is metallised by having metal coloured

coatings applied to one side of the APET during the manufacture of the transfer element.

The image can be printed at step S12 on to the carrier coating applied to the APET transfer element by means of a number of techniques. Various known printing techniques suitable for this include digital printing which, using a computer drawn image, repeatedly produces a high quality image. Various known print heads can be used in such digital printers. However, it should be noted that thermal print heads can degrade the ink since it is sensitive to heat, whereas piezoelectric print heads do not cause excessive heating and degradation of the ink and produce a high quality printed image. When the transfer element is vacuum formed over the surface it is to be printed onto, there will often be distortion, due to stretching, of the transfer element and image. If the contours of the surface that is being printed on are known it is possible to use a computer to distort the image prior to printing step S12 so as to compensate for the image distortion which occurs during the printing process..

For articles of plastics which are liable to melt under the heat which will be applied to perform the image transfer, it is often necessary to support the article on a mould as in step S24. In the event that the heat applied to the article causes it to melt slightly, the mould should prevent deformation of the article.

Referring to Figures 2 and 3, a vacuum forming apparatus 50 comprises a base 52 upon which are located supporting moulds 54. Located on the moulds 54 are the articles 56 onto which an image is to be printed. A transfer element clamp frame 58 is shown in Figures 2 and 3 in a lowered position when the transfer element is being vacuum formed over the articles 56.

Vacuum pump 60 applied a suction, through base 52, to the transfer element causing it to be entirely drawn over articles

56 in a consistent manner. When the transfer element is located over the articles, contoured heating block 62 is lowered over the articles 56, by means of piston 64, so as to apply an even heat to the transfer element thereby transferring the image.

It will be appreciated by persons skilled in the art that the above embodiment has been described by way of example only and not in any limitative sense, and that various alterations and modifications are possible without departure from the scope of the invention as defined by the appended claims. For example, the method of the present invention can be applied to a number of different printing techniques, such as lithographic printing which is most cost effective where large numbers of identical printing operations are involved, or digital printing which is more cost effective, and offers greater flexibility to accommodate changes in the image to be printed, when smaller numbers of articles are to be printed.

CLAIMS

1. A method of printing an image onto a three-dimensional surface, the method comprising:-

printing an image onto a transfer element;

heating said transfer element printed with said image to make the transfer element more flexible;

applying the heated transfer element to said three-dimensional surface with substantially uniform pressure across the area of contact between said transfer element and said surface such that the image faces the surface; and

heating the transfer element to at least partially transfer the image from the transfer element to the three-dimensional surface.

2. A method according to claim 1, wherein said transfer element has a carrier coating and a supporting layer, and said image is printed onto said carrier coating.

3. A method according to claim 2, wherein said supporting layer comprises a sheet of Amorphous Poly Ethylene Terephthlate.

4. A method according to claim 2 or 3, wherein said supporting layer further comprises a metallised coating on at least one surface thereof.

5. A method according to any one of claims 2 to 4, wherein said carrier coating is applied to said supporting layer as an aqueous solution.

6. A method according to any one of claims 2 to 5, wherein said carrier coating is applied to a thickness of substantially 5 to substantially 250 microns.

7. A method according to any one of the preceding claims, further comprising the step of applying a receptor coating to said surface.

8. A method according to claim 7, further comprising the step of applying a base coat to said surface prior to application of said receptor coating to said surface.

9. A method according to claim 8, wherein said base coat is applied by a spraying process.

10. A method according to claim 8 or 9, wherein said base coat is applied to give an average thickness of up to substantially 300 microns of base coat.

11. A method according to any one of claims 8 to 10 wherein said base coat comprises substantially the ratios 100 parts paint primer, 10 to 40 parts catalyst and 15 to 85 parts solvent.

12. A method according to any one of claims 8 to 11, wherein said receptor coating is applied by a spraying process.

13. A method according to any one of claims 8 to 12, wherein said receptor coating is applied to an average thickness of up to substantially 300 microns.

14. A method according to any one of claims 8 to 13, wherein said receptor coating comprises substantially the ratios 100 parts paint primer, 1 to 40 parts catalyst and 15 to 85 parts solvent.

15. A method according to any one of claims 8 to 14, wherein said receptor coating is substantially translucent after application to said surface.

16. A method according to any one of the preceding claims, wherein said step of applying the transfer element to the three-dimensional surface includes vacuum forming the transfer element to the surface.

17. A method according to any one of the preceding claims, wherein said step of printing an image onto said transfer coating is carried out by means of a digital printer.

18. A method according to claim 17, wherein said digital printer has at least one piezoelectric printing head.

19. A method according to any one of the preceding claims, wherein said image is formed from at least one pigment capable of sublimation when heated to a predetermined temperature.

20. A method according to claim 19, wherein the step of applying heat to said transfer element occurs after said vacuum forming step at a temperature so as to cause the sublimation of the or each said pigment.

21. A method according to claim 20, wherein heat is applied to said transfer element at a temperature of between 50 and 450°C for between 10 seconds and 20 minutes.

22. A method according to any one of the preceding claims, further comprising the step of supporting by means of a mould, the article onto which said image is to be printed on a surface thereof other than the surface to be printed on.

23. A method according to claim 22, further comprising the step of controlling the temperature of said mould.

24. A method according to any one of the preceding claims, further comprising the step of heating said transfer element prior to the step of vacuum forming said transfer element to said surface.

25. A method according to claim 24, wherein said transfer element is heated to a temperature between 150 and 600°C for between 1 and 30 seconds.

26. A method according to any one of the preceding claims, wherein the step of applying said heat to said transfer element comprises providing a moulded heating chamber, a surface of which has similar dimensions to said surface of the article, and locating said chamber adjacent the surface of the article, without contact between said moulded heating chamber and said transfer element.

27. A method according to claim 26, wherein the moulded heating chamber has regions which radiate heat at different rates.

28. A method according to any one of claims 1 to 26, wherein the step of applying heat to said transfer element comprises applying said heat by means of hot air.

29. A method according to claim 28, wherein the hot air is applied to the transfer element at a pressure greater than atmospheric pressure.

30. A method according to any one of the preceding claims, further comprising the step of applying a finishing coat to said article after removal of said transfer element from said article.

31. A method according to claim 30, wherein said finishing coat is applied by a spraying process.

32. A method according to claim 30 or 31, wherein said finishing coat is applied to an average thickness of up to 500 microns.

33. A method according to any of claims 30 to 32, wherein said finishing coat as applied comprises substantially the ratios of 100 parts paint primer, 10 to 40 parts catalyst and 15 to 85 parts solvent.

34. A method according to any one of claims 30 to 33, further comprising the step of adding an ultraviolet radiation filtering additive to said finishing coat.

35. A method according to any one of the preceding claims, wherein the image is printed onto a non-planar surface of the article.

36. A method of printing an image onto a surface of an article, the method substantially as hereinbefore described with reference to the accompanying drawings.

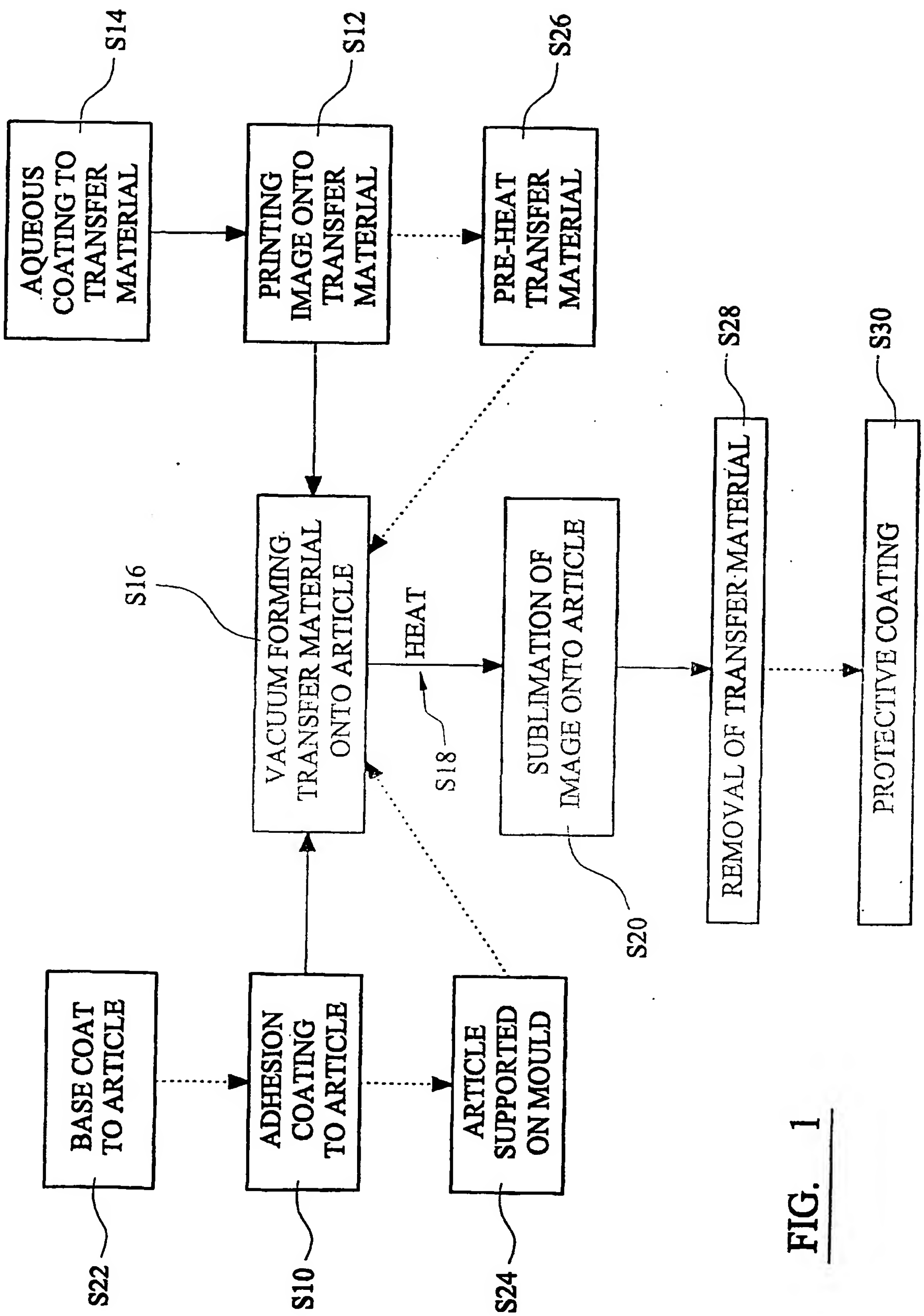
AQUEOUS COATING TO TRANSFER MATERIAL
S14
PRINTING IMAGE ONTO TRANSFER MATERIAL
S12
PRE-HEAT TRANSFER MATERIAL
S26
BASE COAT TO ARTICLE
S22
ADHESION COATING TO ARTICLE
S10
ARTICLE SUPPORTED ON MOULD
S24
VACUUM FORMING TRANSFER MATERIAL ONTO ARTICLE
S16
HEAT
S18
SUBLIMATION OF IMAGE ONTO ARTICLE
S20
REMOVAL OF TRANSFER MATERIAL
S28
PROTECTIVE COATING
S30

FIG. 1

FIG. 2

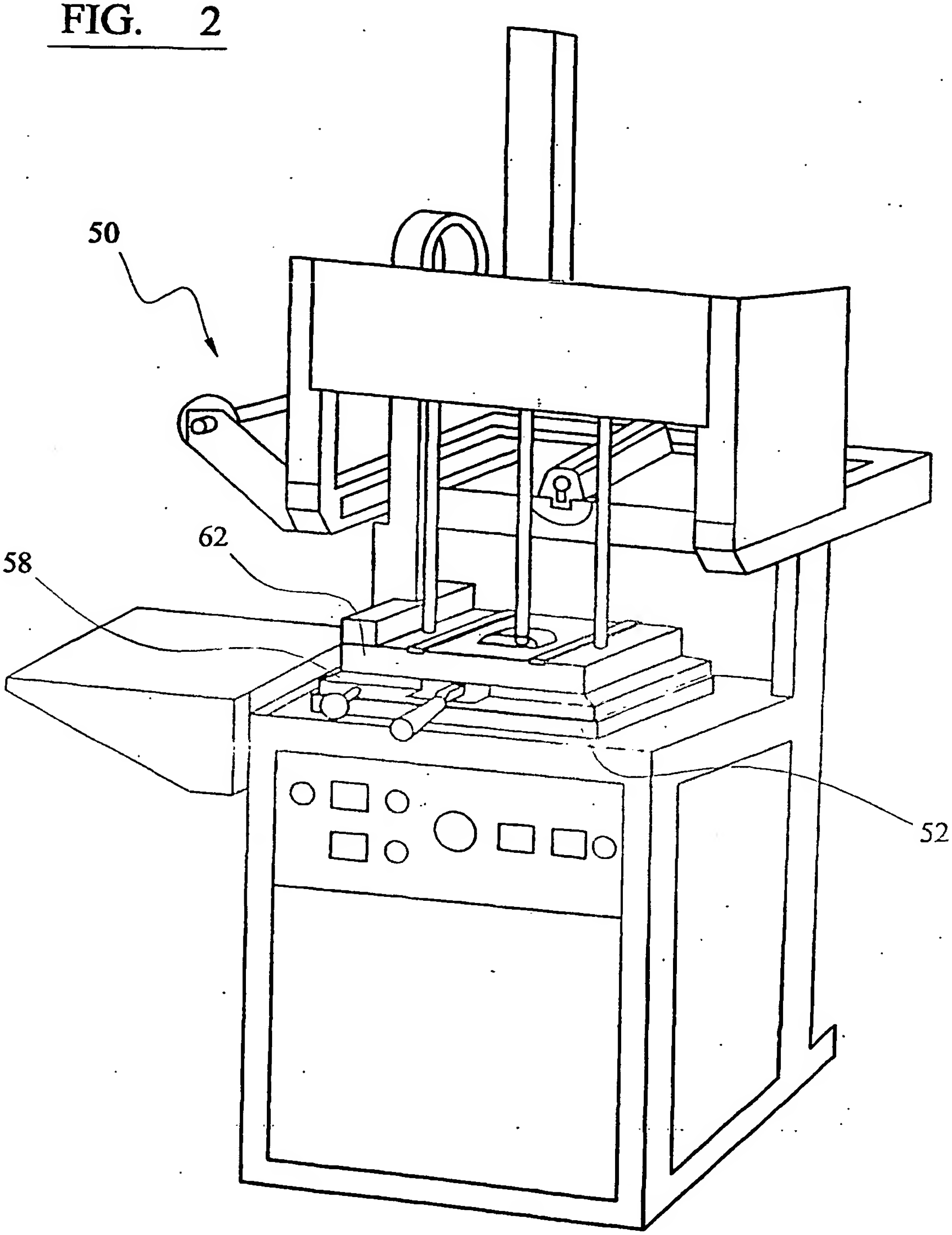

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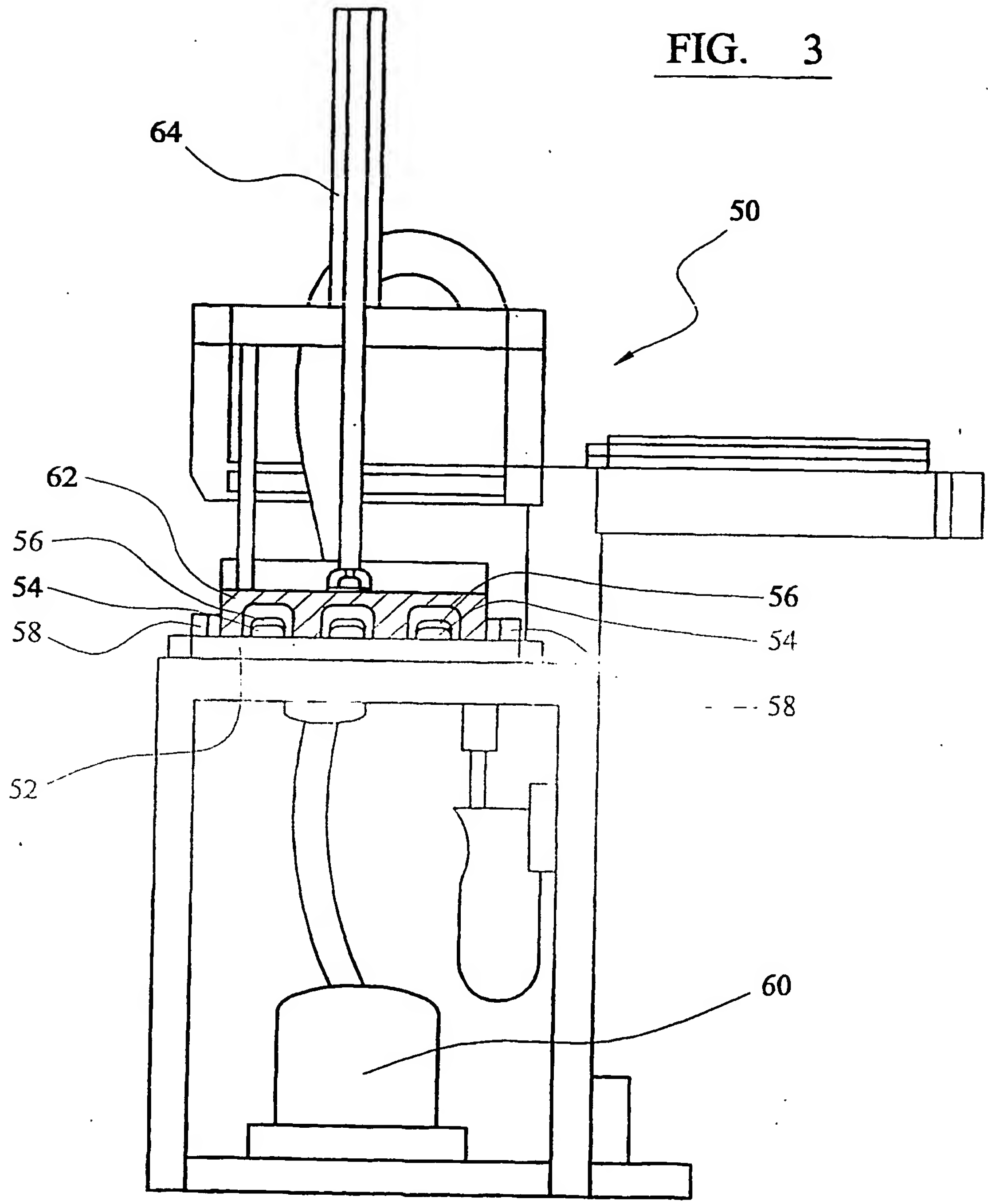
FIG. 3



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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/02577

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B41M5/035

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B41M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 364 130 A (STORK BRABANT BV) 7 April 1978 (1978-04-07) page 2, line 4 - line 39 page 3, line 26 - line 31 page 6, line 10 - line 18 ---	1-36
X	EP 0 511 605 A (BEUTELROCK CAROLIN) 4 November 1992 (1992-11-04) column 3, line 11 - line 27 claims 1-6 ---	1-36
X	EP 0 119 548 A (SCHULZEN HERBERT) 26 September 1984 (1984-09-26) page 3, line 35 -page 5, line 34 page 9, line 15 - line 36 claim 2 ---	1-36

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 August 2001	22/08/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Whelan, N

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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1

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